DOCUMENT RESUME

ED 466 364 SE 066 068

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TITLE Teaching Photography: An Interdisciplinary Theme for Science, Technology, and Art.
PUB DATE 2001-00-00
NOTE 9p.; In: Science and Technology Education: Preparing Future Citizens. Proceedings of the IOSTE Symposium in Southern Europe (1st, Paralimni, Cyprus, April 29-May 2, 2001). Volume I [and] Volume II; see ED 460 860.
PUB TYPE Reports - Descriptive (141) -- Speeches/Meeting Papers (150)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Art Education; Higher Education; *Interdisciplinary Approach; *Photography; Science and Society; *Science Curriculum; Science Instruction; Technology

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This paper addresses contemporary concerns with the disintegration of meaning and fragmentation of knowledge. It appeals to interdisciplinary curricula, where an effort is made to reveal the interactive relationships among different fields of knowledge. The paper proposes Photography as an interdisciplinary theme, which involves Chemistry, Physics, Technology, and Art and gives an outline of the relations and the patterns that connect these fields. Teaching Photography can provide links across disciplines and in addition it would provide a context for experimental work and problem solving. In a photography experiment, STES (Science, Technology, Environment, and Society) oriented curricula could find the basis for developing a dynamic interplay between Science Technology and Art. The proposed interdisciplinary teaching appeals mostly to higher levels of education, universities, colleges, or professional schools. (Contains 14 references.) (Author/YDS)

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Teaching Photography: An Interdisciplinary Theme for Science, Technology, and Art

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ABSTRACT

This paper addresses contemporary concerns with the disintegration of meaning and fragmentation of knowledge. It appeals to interdisciplinary curricula, where an effort is made to reveal the interactive relationships among different fields of knowledge. The paper proposes Photography as an interdisciplinary theme, which involves Chemistry, Physics, Technology and Art and gives an outline of the relations and the patterns that connect these fields. Teaching Photography can provide links across disciplines and in addition it would provide a context for experimental work and problem solving. In photography experiment, STES–oriented curricula could find the basis for developing a dynamic interplay between Science Technology and Art. The proposed interdisciplinary teaching appeals mostly to higher level of education, universities, colleges or professional schools.

KEY WORDS: Technology, Photography, STES– oriented curricula, Fine Art.

INTRODUCTION

In science education curricula, there has been for decades, a strong commitment to disciplinary strength in physics and chemistry. That choice has resulted in failing to strengthen the links between Science, Social / Life Science, Technology or Art. On the other hand, research in science education has shown that there is a need for interdisciplinary knowledge for dealing with the contemporary society's problems. Although most school curricula follow the transitional way, there are some exceptions, where an effort has been made to focus specifically on the interactive relationship among Science, Technology, Environment and Society. In these STES programs are emphasized the social and environmental implications of the development of science and technology (McFadden, 1991). The incorporation of technology education into curricula bridged the gap between science and society. Scientific knowledge is recognized as key to technological development and that development either as a process or product affects human values within the society.

There has been an epistemological debate about the relationship between technology and science. The dominant view accepts *technology as applied science* (Gardner, P.

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1994). This view is based on the assumption that scientific knowledge precedes development of technology. Although technology is consider, as a practical application of scientific theory, there are historical examples that do not support this position. Bell's telephone system was developed in a period where the electrical properties of carbon were unknown. Photography also was invented in a period where chemistry as science did not exist.

The alternative position on the relationship between technology and science states that technology and science are independent to each other and that *technology precedes science* as an intrinsic feature of all cultures (Custer, R. 1995). An intermediate view conceptualizes science and technology as interactive, each contributing to the development of the other.

Fine Art, on the other hand, has been taught as a separate discipline having its own core–elements and its own defined boundaries. Contemporary Art is often close related to Technology applications and in addition artists need to posses scientific knowledge to an adequate level.

Pedagogical implications for education arise from an epistemological consideration of the nature of the technological/scientific knowledge. Is that different from scientific knowledge? Can it be characterized as "content" or "process"? Different emphasis in the balance between conceptual and procedural knowledge has been over time in both technology and science education. These differences actually reflect different emphases of the educational goals within the two areas, and different pedagogic traditions (Murphy, P. and McCormick, R. 1997).

No matter how clear the educational goals and teaching objectives might be, a practical issue of a great importance arises. That is, how to translate these objectives in a STES–oriented course into teaching strategies and assessment methodologies (Zoller, 2000). A difficulty also arises when we have to draw a border line between science and technology or between scientific / technological procedural or conceptual knowledge. When we say that we do science or we do technology. An analogous question holds and in an educational frame of teaching Fine Art.

ON PHOTOGRAPHY

A STES–oriented educational program designed to focus specifically on the interactive relation of science, technology, environment and society, needs interdisciplinary themes to develop curriculum within these expectations. These themes will be the sources of providing teaching material and practical work.

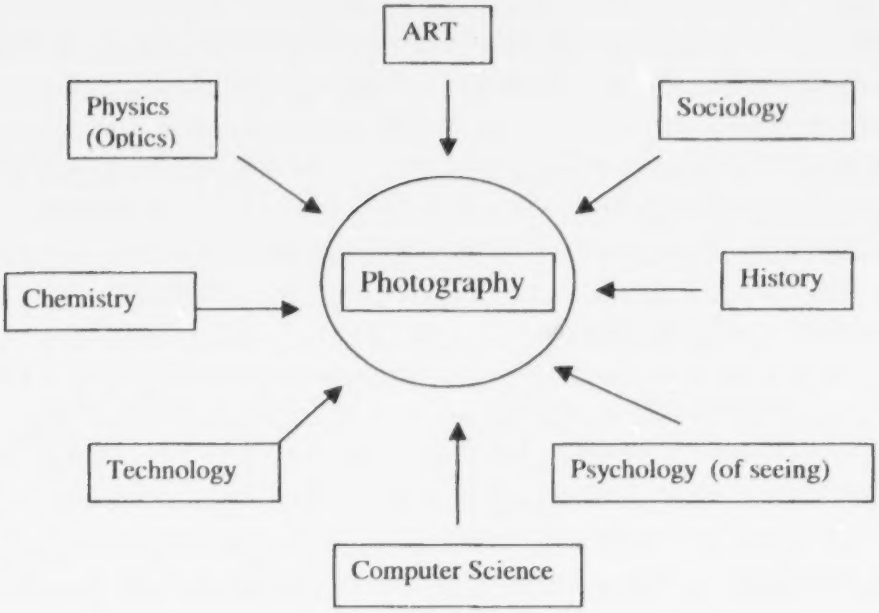

Figure 1. The interdisciplinarity of Photography

We propose that Photography could be such a source, which could provide material for supporting a combined STES program. The interdisciplinarity of Photography is shown in figure 1. Photography is related to physical and to social science as well. It involves a lot of Chemistry and Physics interweaved with Technology. On the other hand a Photograph can be in the center of interest of many social science such as psychology (visual perception), Sociology, Communication, History, Computer Science (digital Imaging) and Fine Art. All the above make Photography being a unique theme, which could approach a variety of fields and provide a context for teaching basic element of chemistry, physics and their technological applications.

Even thought the advances of technology have made Photography as a process a straightforward one, students have always are interested in disenchantment with the 'mystery' of Photography. Photography is very popular among students and sparks their interest to be involved with it. That can make for them a purpose for learning and in addition would provide a context for experimental work and problem solving.

The research literature on intrinsic motivation for learning (Martinez and Haertel 1991) has shown that the dimensions form different models may be organized into three clusters, the cognitive appeal, the mastery appeal and the social appeal. Photography incorporates those dimensions: stimulates curiosity, provides experimental work that lends a sense of effectiveness and enhances sociability.

TABLE 1. Science, Technology and Art in Photographic procedure.

	SCIENCE	TECHNOLOGY	ART
PROCEDURE			
Choose the scene	Light, filter, theory of color		Art-education semiotics
Focus	Linear optics	OPTICS: Lenses	
Choose aperture And speed	Photometry photochemistry Exposure conditions	Use and understand technology equipment	Applying technology to control image aesthetics
Choose Developing time	Control of chemical kinetics	Applying 'trial and error' methods	Control image appearance
Film Development	Photosensitive materials, color production	Use and understand technology equipment, film technology	
Choose the paper		Properties of photographic emulsion	Control image aesthetics
Find printing time – Print the photo		Applying 'trial and error' methods	
Use the photo			Art-education

A sequence of actions or steps, which describe the procedure of making a photograph, is shown in Table 1. There is a broad spectrum of knowledge types, (content or skills) involved in this process. The instructor has the opportunity to introduce basic concepts of physics, such as nature of light, properties of light, linear optics and technology of optics (lenses and geometry of image formation). Chemistry is the other scientific field that can be approached by photography. Concepts of oxidation–reduction could be introduced with experimental work. Factors affecting a reaction, such as pH, restrainers, etc could be studied.

On the other hand, the product, a real–apparent image concerns Mass Media, Communication and Semiotics.

Figure 2 shows patterns that connect Science, Technology and Art, provided by photography.

EXAMPLES OF TOPICS INTERRELATED IN A INTERDISCIPLINARY TEACHING

A dynamic interplay between chemical kinetic and Fine Art

When a photographic material is developed, those silver halide crystal, which have been exposed to light and bearing a latent–image center, are reduced to metallic silver Ag by a reducing agent:

$$AgCl + Red- \rightarrow Ag^{\infty} + Br- + Ox \qquad (1)$$

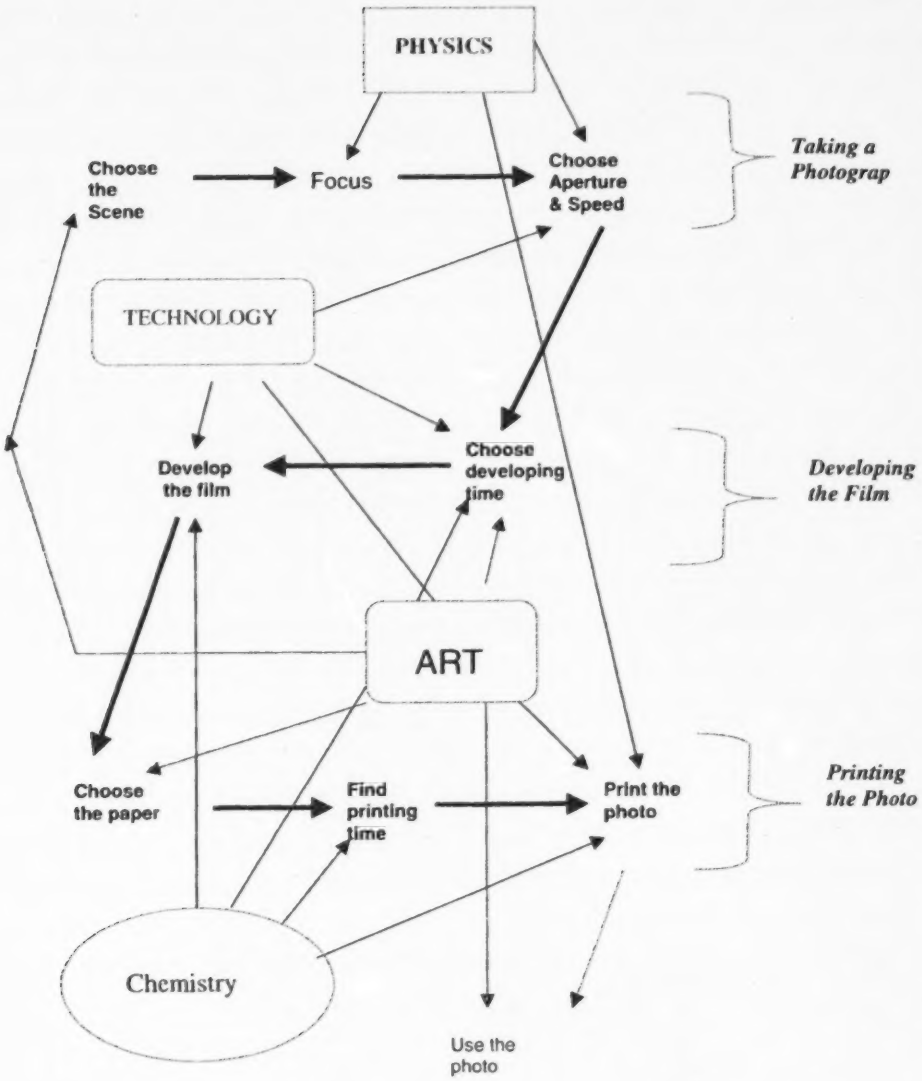

Figure 1. Patterns that connect: Physics, Chemistry, Technology and Art in Photographic process.

Where *Red–* is the developing agent, and Ox is its the oxidized form. The amount of metallic silver formed on a developed transparent emulsion can be estimated by measuring its optical density, *D*. If the optical density *D*, which depends on the geometry of the measuring apparatus, is plotted versus the logarithm of exposure $H = E * t$ (in lux*sec), the characteristic curve is obtained. (Keller, 1993). The slope γ of the linear portion of the graph is the *contrast* of the photographic image. *Contrast* concerns the number of gray tones of the image that exist between absolute black and absolute white. The control of contrast, which is based on a kinetic effect, serves as *artistic expression*. Controlling factors that affect the rate of the reduction reaction, such as temperature or concentration of reducing agent, affect the appearance of the image. Thus the instructor can integrate the chemical kinetic concepts within an Art frame following a dynamic interplay between science and fine Art. This interplay involves the microscopic and macroscopic level. The macroscopic level that concerns Fine Art can be understood in relation the rate of a chemical reaction at microscopic level.

Teaching experimental design using sensitometric procedures

The proposed experiments appeal to a university level course on experimental design. The photographic procedure dealing with a multifactor chemical system is used to collect data for an advanced statistical treatment and introducing chemometrics (Stamovlasis, 2000). The proposed experimental work concerns the determination of a photographic parameter, *the contrast*, γ, which is the slope of the characteristic curve of a photographic film. In practical sensitometry the determination of Á has been based on the "single–factor–at–a–time" approach. This work is a stochastic approach to development kinetics of a photographic emulsion. The obtained stochastic models predict *contrast* as a function of temperature, developing time and concentration of reducing agent. The results are useful to a professional artist photographer and to the college photography Lab, if available. This work is a demonstration of using easy popular experiments in a Fine Art frame to teach advanced statistical methods.

Project works

The process of creating a photograph (figure 2) involves 'content' and 'procedural' knowledge, that is knowledge, which consists of understanding basic scientific theories, and knowledge, which is of 'know how' type. Instead of using explicit teaching on design and technology, that is describing a set of preordered behaviours, one can organized project work based on the intension to investigate or to evaluate something. A simple example could be an 'investigation' of the effect of color temperature of a light source on the appearance a color photograph. That connects physics and chemistry and within technology education can provide the context of proposal making and enhancing active and reflective capabilities. These project works can be designed and evaluated within a dynamical model (APU, 1987) demonstrating the interplay between thought an action.

Other interdisciplinary projects

Interdisciplinary projects connecting also social and physical science can be designed as well. Photographic Aesthetic, through its history from collodion to hydroquinone (Newhall, 1982) has been related to chemical materials and method used. Thus, patterns that connect Chemistry, History and Art can be drawn, and which contribute to reduction of fragmentation of knowledge.

CONCLUDING REMARKS

The paper proposed that Photography, because of its scientific, technological and social dimension, interrelates many topics and fields and that makes it a suitable context for interdisciplinary teaching. Photography can provide STES–oriented curricula with easy and interesting experiments for practical work and problem solving. The interdisciplinary approach applies to chemistry, physics or technology teaching, but also in teaching of photography itself, replacing in this way the rote learning of applying preordered procedures with constructivist meaningful learning.

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Title: Proceedings of the 1st IOSTE Symposium in Southern Europe

1. Valanides, N. (Ed.). (2001). Proceedings of the 1st IOSTE Symposium in Southern Europe-Science and technology education: Preparing future citizens, Vol. I (pp. 456). (Section 1: Relevant teaching, incorporating curriculum, teaching approaches and assessment aspects. Section 2: Environmental issues including sustainable development and a culture of peace. Nicosia, Cyprus: Imprinta (2001).

2. Valanides, N. (Ed.). (2001). Proceedings of the 1st IOSTE Symposium in Southern Europe-Science and technology education: Preparing future citizens. Vol. II (pp. 400). (Section 1: Action research involving classroom related studies and professional development studies. Section 2:Resources supporting teaching, including locally produced equipment. Visualization ideas using new technologies.) Nicosia, Cyprus: Imprinta Ltd.

Author(s): Multiple authors

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Organizer of the Symposium : Nicos Valanides	April 2001

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